Modeling Sustainable Design in Building Construction

Abstract

At the DOE, laboratory structures use more energy and water than typical office buildings and provide an opportunity to achieve tremendous pollution prevention (P2) results. Los Alamos National Laboratory's project team, with the contractor, Hensel Phelps, created a model facility with high-quality sustainable design elements that meet stringent environmental standards. The Strategic Computing Complex demonstrates outstanding waste-prevention, recycling, affirmative procurement, energy-saving, and cost-saving results that offer inspiring examples to builders and designers throughout DOE. Results include: 40% annual water use reduction; \$574,000 savings in water cost; and \$1 million saved in structural steel and labor costs.

Introduction

DOE building construction, particularly at laboratory facilities, represents a tremendous opportunity for reducing waste and pollution across the country. Construction and demolition waste comprises approximately 25% of the solid waste stream in the United States. In addition to that waste, the typical laboratory structure uses far more energy and water per square foot than a typical office building. The Strategic Computing Complex (SCC) at Los Alamos National Laboratory (LANL) is an outstanding example of waste prevention, recycling, affirmative procurement, energy-saving, and cost-saving results that can be achieved in contemporary building construction throughout the DOE complex.

In evaluating the sustainability of the SCC design, the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Rating System™ has been used as a general guide. LEED™ is a system for rating new and existing commercial, institutional, and high-rise residential buildings. It is based on accepted energy and environmental principles, was developed with input from all segments of the building industry, and has been open to public scrutiny. The SCC meets many of the LEED™ guidelines, which are more stringent than state or federal regulations.

SCC accomplishments will receive broad publicity. A sustainable design report about the SCC has already been published in LANL's *P2 Weekly Accomplishments*, which is distributed throughout the DOE complex. Publication is also planned for *ESave*, DOE's defense program pollution prevention newsletter; and for the *Sustainable Design Program* webpage of Pacific Northwest National Laboratory (PNNL). PNNL's *Project Showcases* web-window highlights sustainable design success stories. These publications featuring the SCC are expected to be available within the next three to six months.

The Strategic Computing Complex

The SCC is the premier facility at LANL. It contains three stories, over 300,000 square feet, and houses the world's largest and fastest computer (Figure 1). The computer is capable of simulating highly complex phenomena and will play an important part in the DOE's role as steward of the nation's nuclear stockpile. LANL is located in northern New Mexico's picturesque high desert environment and is surrounded by

Figure 1. Artist's Rendering of the Strategic Computing Complex at LANL: 300,000 square-feet and three stories.

arid plateaus and mountains. The facility design has successfully integrated this large structure into a natural landscape in an aesthetic, environmentally conscious way, promoting the health and safety of employees and the public alike.

LANL's design team (Figure 2) played a key role in incorporating innovative waste-prevention design elements into the project. Highly flexible and scalable aspects of the SCC's mechanical and electrical systems provide means for reducing waste and increasing efficiency over the life of the complex, and provide a model for significant cost-saving opportunities throughout DOE. These design features have also resulted in enhanced indoor environmental quality. Energy-efficient and high quality lighting, heating, and architectural elements have been combined to create a healthy, pleasant atmosphere for staff.

Figure 2. LANL Project Team
First row (left to right): Rachel Taylor, Rose Montaño.
Second row: Mark Harris, John Bretzke, Al Guerra, Laura Hanson, Steve Barret, Tom Fitzgerald, Judson Ford. Third row: Nick Nagy, Steve Day, Phil Sena, Myron Koop, Bill Bryant.
Top of photo: David McBrayer.

Planning for Sustainability

A sustainable site is one that addresses fundamental environmental considerations before any groundwork occurs. A site previously occupied by a gas station and large parking lot was selected for the SCC. Those structures were deconstructed and remediated—no new ground was broken and no natural resources were degraded to make way for the SCC. In fact, where there had been approximately 0% to 10% vegetative cover, there now is approximately 25% to 30%. The landscape design uses native and/or drought tolerant plants requiring no, low or moderate water usage in Los Alamos' arid climate (see below for more information).

Stormwater management was carefully monitored and daily maintenance reduced runoff and erosion that might pollute the watershed. To reduce light pollution, the adjacent parking lot is equipped with full cut-off luminaires that direct light downward. The lighting design also calls for fewer fixtures, preventing waste from over-lighting. Maximum illumination for the parking lot is very efficient at one footcandle. A programmable dimming system and daylight-sensitive photocells regulate all outdoor lighting.

Water Efficiency

Water use was especially minimized through the landscape and cooling system designs. Again, all plants used in the landscaping are native or drought-tolerant. In addition to having lower irrigation requirements, these will require less fertilizer and fewer pesticides, thereby reducing costs and water-quality impacts. Plants that are not native are expected to naturalize to the light, soil, and water regime of the area and their water requirements will diminish over time. For some plants, no additional watering will be necessary once they have become established. The entire irrigation system is fully automated and will run on multiple programs to allow different watering regimes for different plant groups, including low-flow and no watering. Some water is harvested via cobble swales on the north and east sides of the building and will be directed to vegetation growing there. Water will also be harvested off the hardscape in the plaza area and directed to plants in that vicinity.

Inside the building, design changes in the cooling system from many small cooling towers to three large ones resulted in efficiency gains (Figure 3). This enabled the SCC to come online with no additional withdrawal of water from the aquifer. Instead, treated sanitary wastewater from the LANL complex is recycled through the system. One year after start-up, a new treatment facility located at LANL will implement a different process for treating water. To further increase cooling tower efficiency, the new technology (either reverse osmosis filtration or a lime softening process) will remove silica from the water. This will dramatically reduce annual

Figure 3. A design change to 3 large cooling towers resulted in efficiency gains.

water use and costs (Table 1). It will also reduce the amount of chemicals used to treat the water.

public research laboratories achieve energy efficiency improvements of 30 percent, then the United States could reduce annual electricity consumption by 84 trillion Btu's. This figure equals the electricity consumed by 2.1 million U.S. households. This improvement would save $1.25 billion in utility costs, reduce carbon dioxide emissions by 16.4 million tons, and remove the equivalent of 3 million automobiles from U.S. highways each year (Figure 4). The SCC is doing its part in the following ways.

Centralized steam from the LANL steam plant is used for heating the SCC and all resulting condensate is returned to the plant. Three cooling towers and four chillers will cool the computers and the rest of the building. Chillers are regulated according to load and can be taken off-line as demands decrease. The cooling system design also allows for free-cooling when outside temperatures are low—incoming water does not need to be cooled and is run directly through the heat exchangers to cool water in the loop. The computer's mechanical and electrical room is located beneath the computer room and serves as an efficient under-floor plenum.

Just as chillers offer varying levels of efficiency, refrigerants themselves range in efficiency. At the SCC, HCFC/R-123 is the refrigerant used to cool the building. Among refrigerants currently

Table 1
Anticipated Annual Water Use and Cost Savings through Additional Treatment

FY 2002-2004		FY 2005	
Current Treatment	Additional Treatment	Current Treatment	Additional Treatment
156 acre-feet	87 acre-feet	462 acre-feet	257 acre-feet
69 acre-feet (22.5 million gallons) water saved		**205 acre-feet (66.8 million gallons) water saved**	
Cost		Cost	
$277,000	$214,000	$816,000	$242,000
$63,000 saved		**$574,000 saved**	

Based on $2.17/1000 gallons and 326,000 gallons/acre-foot.

Energy and Atmosphere

According to USEPA estimates, if half of the nation's approximately 150,000 private and

on the market, R-123 is the most efficient. Its kW/ton rating has the lowest range at 0.48 to 0.67. R-123 also has the lowest ozone depleting

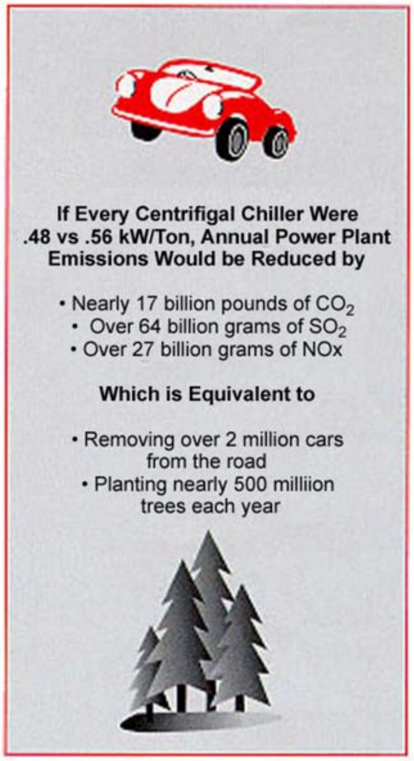

Figure 4.

potential at 0.02, and the lowest global warming potential at 93, of any HCFC.

Autoclaved aerated concrete (AAC) blocks were used throughout the building. The autoclaving process, similar to that used in hospitals, serves to cure the concrete. The result is a lightweight block that is stronger and one-fifth the density of conventional concrete. The lighter weight of AAC reduced some of the handling costs associated with concrete construction and reduced structural steel and associated labor costs by $1 million. These blocks are more insulating than regular concrete, which reduced the need for fiberglass wall insulation. Triple-paned tinted windows in the hallways also provide high insulation value by reducing heat loss or gain through the building's glazing.

Reducing heat islands at a site helps reduce facility energy demands. At the SCC, the landscape structure will help reduce heat island effects. These will be further mitigated by the installation of an Energy Star-compliant, white plastic roofing membrane that will cover the entire building. It will sit over an R-30 insulation layer and is highly durable with an expected life span of 15 to 20 years. When compared with gravel and black roofing materials, the membrane system is estimated to save $4,900 and $8,900 in energy costs over a ten-year period, respectively.

The SCC also utilizes premium efficiency motors and variable-frequency drives (VFD). A VFD is an electronic device that provides power at varying frequencies, making it possible for induction motors to operate at anywhere from 10% to 300% of their nominal fixed speed. This reduces energy use of a motor-driven system by 10% to 50% or more. The reduced demands in electricity at the SCC will likewise reduce demands on coal-fired plants, helping to reduce pollution in the region.

Materials and Resources

As mentioned, construction and demolition waste makes up approximately 25% of the solid waste stream in the U.S. Procurement of materials and services can help improve the overall sustainability of a building. Using local providers reduces environmental releases resulting from transportation and supports the local economy. The contractor, Hensel Phelps, achieved positive affirmative procurement results by meeting 15% of their subcontractor and supplier needs through businesses located in the northern eight counties of New Mexico.

Uncontaminated asphalt and soil were collected in the deconstruction of the original site. They were stockpiled for reuse as paving and fill materials at other LANL sites. The quantity of recovered materials would be enough to pave a road two-thirds of a mile long and bury a football field under 20 feet of dirt (Figure 5).

LANL also has a highly comprehensive recycling program that will be implemented at

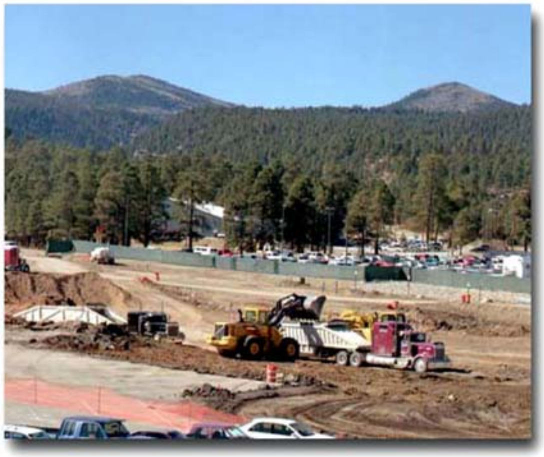

Figure 5. 34,000 cubic yards of soil and 2,600 tons of asphalt were collected during deconstruction and stockpiled for reuse.

the SCC in accordance with practices used throughout the laboratory. In addition, many of the materials used in the SCC contain recycled content (Table 2). The furniture is made from recycled materials. This and many other products, such as the AAC and carpeting, are recyclable.

Table 2 Recycled Content Percentages of Materials Used in the SCC	
Particleboard (100%)	Structural Steel (96%)
Ceiling tiles (42%)	Ceramic wall tiles (8%)
Ceiling suspension steel (25%)	Roofing sealant insulation (10%)
Acoustical wall treatment boards (50%)	Fiberglass wall insulation (25%)
Roofing insulation (polyisocyanurate) (9%)	

Indoor Environmental Quality

Studies have shown that indoor environmental quality (IEQ) improvements can increase worker productivity by as much as 16%, leading to rapid payback for IEQ investments. Volatile organic compounds (VOC) and formaldehyde are two major concerns with regard to IEQ. At the SCC, four of the paints (all Health Spec brand) and the carpet adhesive used throughout the building contain no VOCs at all. Fifty percent of other paints, coatings and sealants have VOC levels at or below LEED™ Rating System limits (see page 1). Decorative panels, laminates, particleboard, and all carpet products meet either federal guidelines or the Carpet and Rug Institute's green label guidelines regarding VOC and formaldehyde releases.

Lighting is also critical in IEQ considerations. At the SCC, a large atrium draws daylight to the interior of the building. For artificial lighting, the interior of the SCC is equipped almost entirely with fluorescent lamps (70% of which are high-quality ALTO brand). Fluorescent lamps are very efficient and have long lamp lives. Electronic, high-frequency ballasts were used throughout the building. They are estimated to result in an overall efficacy (lumens per watt) increase of 15% to 20% over magnetic ballasts, while consuming up to 30% less power. Forty-three percent of the luminaires were equipped with ballasts that allowed 3 or 4 lamps per fixture rather than 1 or 2, thereby reducing installation and labor costs. All offices are equipped with motion sensors and 3-way wall switches. Motion sensors provide estimated energy savings of 25% to 50% for offices and 45% to 65% for conference rooms.

To encourage staff use of alternative transportation, showers have been installed to facilitate bicycle commuting. High-occupancy-vehicle parking spaces are provided for car-pooling, and the LANL shuttle service connects to the Los Alamos County bus system.

The SCC—A Model Facility

The LANL project team and the contractor, Hensel Phelps, have made an outstanding contribution to DOE waste prevention, recycling, and affirmative procurement objectives. They provide inspiring leadership for achieving sustainable design and construction results that prevent waste and pollution. Many positive features of the SCC contributed to waste reduction and cost savings. Among these was the use of autoclaved aerated concrete, which reduced structural steel and labor costs by $1 million. Health Spec paints containing no VOCs contribute to improved employee health and productivity. High quality, high-efficiency ALTO fluorescent lamps provide 70% of the indoor lighting. Motion sensors are reducing energy use by 25% to 65%. Variable frequency drives provide 10% to 50% energy savings. Design changes in the cooling system will result in water use reductions of 67 million gallons and $574,000 annually, by FY2005. The SCC model is available for application in other construction projects throughout the DOE complex.

Individuals nominated to receive the DOE P2 Award for their work on this project are John Bretzke, Nicholas Nagy, and Gary Johnson. For more information, contact John Bretzke at (505) 665-3867. For information about LANL's Environmental Stewardship Program, contact Tom Starke at (505) 667-6639.

Figure 6. Looking west at the Strategic Computing Complex and the foothills of the Jemez Mountains.